
5 Concrete Placement

Testing

Entrained Air

Slump

Strength

Water/Cementitious Ratio

Mixing

Placing

Concrete Compressive Test Specimens

Curing

De-Tensioning

Multiple Strand Release

Single Strand Release

Draped Pre-Tensioned Strands

Removal of Forms

Sealing of Surfaces

CHAPTER FIVE:

CONCRETE PLACEMENT

Concrete used to produce precast prestressed structural members is required to be batched in an approved plant meeting the requirements of ITM 405. A Quality Control Plan (QCP) is prepared by the vendor in accordance with ITM 803. This plan is approved by the DTE before production begins.

TESTING

All QC concrete testing is performed by a Technician employed by the Fabricator. All concrete testing for structural members will be monitored by a Qualified Technician employed by INDOT. This is the QA oversight. If, as directed by the DTE, the Qualified Technician employed by INDOT cannot be present for the compression testing to verify the minimum strength for prestress release has been achieved, the Fabricator may proceed with the compressive strength testing. The Fabricator is required to complete the Certification of Compliance for Release of Prestress Force (Appendix A) and provide this document to the Qualified Technician. When the above procedure is used, INDOT is required to obtain test cylinders to perform verification compressive strength testing. The frequency of verification testing is determined by the DTE. The INDOT Technician is required to notify the Fabricator that additional compressive strength cylinders are required at the time the beam is cast.

The Fabricator Technician may be either Certified or Qualified. Certification may be obtained from a trade organization such as American Concrete Institute (ACI), Precast/Prestressed Concrete Institute (PCI), or through INDOT. Qualification is obtained through the Independent Assurance Program. A Qualified Technician is required to pass a written exam and demonstrate proficiency for each individual test that is performed. The written test and demonstration of proficiency are given by an Independent Assurance Technician (IAT) located in each INDOT District. Required tests include the air content, compressive strength, making and curing specimens, sampling concrete, slump, yield, moisture content of aggregate, sampling aggregates, and water/cementitious ratio. Fabricator Technicians are required to demonstrate proficiency to the IAT every year. All Certified and Qualified Technicians are entered into the SiteManager log of Technicians.

ENTRAINED AIR

Concrete used in precast prestressed structural members is required to be air entrained. Air entraining and other types of concrete admixtures are maintained on an Approved List by the Office of Materials Management.

Air content is determined by AASHTO T 152 or ASTM C 173 for lightweight concrete. Air content tests are made in accordance with the requirements of the Manual for Frequency Manual or as directed by the Fabrication Supervisor. The results of all tests are shared between INDOT and the Fabricator. Tests for entrained air are required to be made on concrete containing the same materials and using the same type mixer and mixing procedure used for the structural member. The air test is taken as close as possible to the work location.

The air content is required to be $6.5\% \pm 1.5\%$. If the air content tests are not consistently within specification requirements, additional air content tests are required to be performed and recorded until the air content is consistent. Hot temperatures, new admixtures, and the first batch of the day may sometimes attribute to the air content not being within the specification requirements.

SLUMP

The concrete is required to be workable and of the desired consistency. The slump test is a measure of this workability and consistency and is required to be conducted in accordance with Section **505.01**. Acceptable slump ranges are designated in Section **707.04**. Slump tests are made in accordance with the requirements of the Frequency Manual or as directed by the Fabrication Supervisor.

STRENGTH

Precast members that are not prestressed are required to have a minimum compressive strength of 4500 psi in 28 days in accordance with Section **707.04**. All tests are monitored by the INDOT Technician and the results will be readily available.

WATER / CEMENTITIOUS RATIO

The maximum water cementitious ratio is required to comply with Section **707** and ITM 403. The total of Portland cement and other cementitious material may not exceed 800 lbs/cu.yd.

MIXING

Concrete materials are required to be stored, produced, and transported under applicable provisions of Section **702.07** and **702.09**.

Concrete for structural members is usually mixed on-site in a stationary mixer, truck mounted mixer, or a combination of the two. Ready-mixed concrete from an approved plant is also acceptable if not more than 30 minutes elapses from the time mixing water is added and the mix is deposited in the forms.

The batch-mixer is required to be approved by the Engineer and meet the following:

- 1) Provide a uniform distribution of the materials
- 2) Operate at the rated capacity or less
- 3) Be equipped with a mechanical means to prevent the addition of materials once mixing is started
- 4) Contents of drum are entirely emptied before the next batch is started

PLACING

Concrete is required to be placed in a continuous operation in accordance with Sections **707.06** and **702.20** to produce a monolithic structural member free of any cold joints, areas of segregation, honeycomb, or planes of separation between layers.

Concrete is placed in the forms in such a manner that the concrete does not free fall more than 5 ft and that no segregation occurs. The concrete is placed in uniform layers and thoroughly compacted during and immediately after placing, and vibrated (Figure 5-1).



Figure 5-1. Vibrating the Concrete

Section **707.04(a)** allows a tight coat of concrete grout on reinforcing bars to extend a maximum of 1/2 in. from the top of the structural member. All loose and flaky material is required to be removed from the reinforcing bars. Plastic bags are often used to prevent excess concrete from drying on the reinforcing bar during concrete placement (Figure 5-2).



Figure 5-2. Plastic Bags on Reinforcing Bars

Hangers (Figure 5-3) and clips are supplied by the Contractor for false work. The Contractor provides the location and spacing of the hardware if the locations are not shown on the shop drawings.



Figure 5-3. Placing Hangers

Floating or screeding the top of the concrete is done to obtain a smooth finish (Figure 5-4). Shop drawings will indicate the amount and frequency of the transverse scoring. Excess concrete on the tops of the forms is required to be removed.



Figure 5-4. Concrete Finish

In the event that there is a significant time delay between lifts, the Technician is required to check the concrete in the bed. The vibrators are required to easily penetrate and consolidate the concrete. Extra work is required between the lifts to ensure proper consolidation of the subsequent lifts. The Technician is also required to record the time that the trucks arrive at the bed.

CONCRETE COMPRESSIVE TEST SPECIMENS

During placement of the concrete, the Technician monitors the making of concrete compressive test specimens. These specimens are made in accordance with Section **707.04(c) 3**, and the Frequency Manual designates the number of compressive test specimens that are required. A cylinder set consists of at least three cylinders obtained from three separate batches or loads of concrete used in casting a structural member. This cylinder set is required when at least three or more loads of concrete are needed for each member. When only one to two loads are required for each member, at least one cylinder is required for each load. When the pour is large, testing the first load of concrete is necessary and cylinders are required to be made from this load.

Compressive test specimens are made in accordance with AASHTO T 23. The cylinders are required to be 6 in. in diameter and 12 in. in height and cured at the same location and in the same manner as the structural member (Figure 5-5). Special care is taken to not disturb the concrete cylinders during the initial set of the concrete. Cylinders are placed on or near the casting bed so that the concrete is not disturbed by nearby vibrators or workers.



Figure 5-5. Curing Concrete Specimens

Concrete test specimen tags are required to indicate the contract number, job number, beam identification, location of the test in the beam, the date poured, and the initials of the Technician (Figure 5-6).



Figure 5-6. Concrete Specimen Tags

CURING

Curing may be done by accelerated curing or by wet curing in accordance with Section **707.07** and AASHTO T 23 (10.2). For accelerated curing in accordance with Section **707.07 (b)**, low pressure steam is usually used; however, radiant heat may be used. The casting bed for any unit cured with steam is required to be completely enclosed by a suitable type of housing and tightly constructed to minimize heat and moisture loss.

Water curing methods, such as covering the top of the freshly set concrete with wet burlap (Figure 5-7), are used from the time the concrete is placed. Tarps (Figure 5-8) are placed over the forms after the burlap is placed.



Figure 5-7. Wet Curing with Burlap



Figure 5-8. Wet Curing with Tarps

Curing is maintained until the concrete meets the minimum required strength for detensioning. In discontinuing the steam application, the air temperature inside the enclosure is required to decrease at a rate not to exceed 50°F per hour until a temperature has reached at least 40°F above the temperature of the air which the concrete is exposed. Recording thermometers are required to be provided by the Fabricator and are used to check these temperature requirements. The temperature of the concrete shall not exceed 158°F.

DE-TENSIONING

The inspection of the finished product starts with the de-tensioning operation. This occurs after the strands have been stressed, the conventional reinforcement has been placed, the forms have been positioned, all hardware and accessories have been installed, and the concrete placed and cured. Forms which may restrict either horizontal or vertical movement of prestressed members are stripped, or at least loosened, prior to de-tensioning.

Unless otherwise specified on the detail plans or approved shop drawings, the minimum compressive strength of the concrete at the time of the prestressing is required to be at least 4000 psi. This value is determined from compressive test specimens made at the time the beam was cast. If the concrete has been steam cured, the prestressing operation is required to be done while the concrete is still warm and moist.

The prestressing of the concrete beam requires cutting or releasing of the tensioned strands outside the ends of the beam which transfers the tension load in the strand from the anchoring abutments to the concrete beam. The top strand is required to be detensioned first (Figure 5- 9).



Figure 5-9. Detensioning Top Strand

The bottom strand is then detensioned symmetrically about the center line (Figure 5-10). Each end of the strands is cut in the same manner at the same time. Specific details of the detensioning sequence are listed on the shop drawings.



Figure 5-10. Detensioning Bottom Strand

Concrete changes in dimension because of temperature change and shrinkage. The temperature of structural members is required to be held reasonably constant during the curing period, especially during the latter half of the curing period. If the concrete is permitted to dry and cool for any length of time prior to prestressing, dimensional changes take place which may cause cracks or undesirable stresses in the concrete due to restraint caused by the prestressing strands. This is especially true if hold-downs are used to deflect strands. Therefore, de-tensioning is done immediately following the curing period and when test cylinder strengths indicate that the required minimum compressive strength has been obtained. Prestressing forces are never applied to a member until the required minimum compressive strength of the concrete has been obtained. In all de-tensioning operations, the prestressing forces are required to be kept symmetrical about the vertical axis of the member and be applied in such a manner to prevent any sudden or shock loading.

MULTIPLE STRAND RELEASE

The strands may be released simultaneously by hydraulic jacking. With this method, the total force is taken from the header by the jack and gradually released. Some sliding of the members on the bed may occur. The amount of sliding is proportional to the exposed lengths of the stressed strands between members and between the last member and the fixed end. To minimize sliding, these lengths are held to a practical minimum. Structural members stressed by this method are required to be free from all restrictive movement, other than sliding friction on the bed.

SINGLE STRAND RELEASE

Single strands may be released by heating and gradually parting the strands. Heating is done on each strand simultaneously at both ends of the prestressing bed and preferably at all spaces between the ends of adjacent members. Where spaces between the ends of adjacent members are short, simultaneous heating at all spaces between members may not be required; however, any allowance is required to be in accordance with the approved sequence. For release of the strands to occur gradually, the ends are not quickly cut and are heated until the metal gradually loses strength. Heating is done with a large low-oxygen flame that is applied along the strands at 2 in. to 5 in. in width. Strands are heated in such a manner that failure of the first wire in each strand occurs after the torch has been applied for approximately 5 seconds or preferably longer.

Symmetry of release is required to be observed at each beam end. Strands are cut one at a time on opposite sides of the center line so the sequence used keeps the stresses nearly symmetrical about the axis of the structural members.

DRAPED PRE-TENSIONED STRANDS

Unless the plans or specification indicate otherwise, draped pre-tensioned strands are required to be de-tensioned using the following procedure:

- 1) Release the tension in the draped strands at the ends of the structural members by heating each strand until failure. The draped strands are heated to failure at each uplifted point in accordance with the approved sequence or as shown on the shop drawings.
- 2) All hold-down devices for the draped strands are released and the hold-down bolts within the members removed
- 3) If any straight pre-tensioned strands are located within the members, the straight strands are de-tensioned after the draped strands have been de-tensioned. Straight strands may be de-tensioned by either the single-strand or multiple strand release method.
- 4) Procedures for transfer of prestressing forces to structural members with deflected pre-tensioned strands are followed.

REMOVAL OF FORMS

In accordance with Section **707.07**, side forms may be removed when there will be no distortion, slump, or misalignment of the concrete. The side forms are removed with a crane after all of the bolts for the inserts have been removed. The beam is then lifted from the bed by the crane (Figure 5-11) and transported to the storage area.



Figure 5-11. Beam Removal

SEALING OF SURFACES

The outside vertical faces of fascia girders and the exposed face and top of the curb section are finished in accordance with Section **702.21**. The tops of all beams and the outside faces of the fascia beams are sealed with an approved concrete sealer in accordance with Sections **707.06** and **709** (Figure 5-12).

The list of approved Proprietary Portland Cement Concrete Sealers may be obtained from the following:

<http://www.in.gov/indot/div/mt/appmat/pubs/apl29.pdf>



Figure 5-12. Sealing Beams

The concrete surface is required to be at least 28 days old. If the beams are shipped prior to 28 days, the beams are required to be sealed at the job-site. The Technician will inform the PE at the job-site of this sealing requirement by e-mail as well as noting the need for sealing on the Yellow Shipping Cards.

The sealer and ambient and surface temperatures at the time of sealing are required to be between 40°F and 100°F. Silane sealers may not be applied if the ambient temperature is expected to drop below 40°F in the next 12 h.

If rain has occurred, the concrete surfaces are dried at least 48 h before sealing. Sealers are not applied if standing water is visible. Silane sealers require at least 4 h to dry in 70°F weather at 50% humidity. Drying times are longer in cooler or more humid conditions. If rain is expected before the drying time is completed, the structural beams are required to be covered appropriately.